Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Promoting Expanded Opportunities for Radio Experimentation and Market Trials under Part 5 of the Commission's Rules and Streamlining Other Related Rules	)	ET Docket No. 10-236
	)	
2006 Biennial Review of Telecommunications Regulations – Part 2 Administered by the Office of Engineering and Technology (OET)	)	ET Docket No. 06-105

REPLY COMMENTS OF V-COMM, L.L.C.

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V-COMM, L.L.C. (V-COMM)[1] submits reply comments in response to the FCC's Notice of Proposed Rulemaking (NPRM) in the above-captioned proceeding.[2]

I. INTRODUCTION AND SUMMARY

In response to the FCC's NPRM on experimental licensing and market trials, V-COMM analyzed the comments submitted in the proceeding and prepared these reply comments. The NPRM seeks comments on enhancing the development of innovative and new technologies by expanding the scope of its radio experimental licensing program pursuant to Part 5 of its rules. Herein, we address the comments and technical issues associated with the FCC's proposed

[1] V-COMM, L.L.C. is a wireless telecommunications consulting company with principal members having over 29 years experience in the wireless industry. We have provided our expertise to wireless operators in RF engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. We have extensive industry experience in all CMRS technologies. V-COMM's company information and experiences are highlighted in this report's Appendix A, along with biographies of senior members of its engineering team. Verizon Wireless retained V-COMM to evaluate the comments submitted in the NPRM proceeding and their potential impact on wireless networks.

expansion of its experimental licensing authorizations for applications in licensed Commercial Mobile Radio Service (CMRS) bands (i.e. Cellular, PCS, AWS, SMR, 700MHz bands, etc.). Previously, V-COMM submitted comments in this NPRM proceeding on March 10, 2011.[3] V-COMM also submitted comments and reply comments in the FCC's Dynamic Spectrum Use Technologies Notice of Inquiry (NOI) proceeding,[4] on February 28, 2011 and March 28, 2011.[5] Therein, we provided reasons that opportunistic underlay spectrum sharing technologies are not compatible with and will cause harmful interference to existing licensed CMRS services.

V-COMM is an independent engineering firm with extensive experience in CMRS technologies and systems. We have significant experience in CMRS and Public Safety network design and deployments, engineering networks for high performance, optimizing spectrum efficiency, and evaluating new wireless technologies. V-COMM has conducted extensive interference and compatibility studies within CMRS networks,[6] performed noise and interference

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[2] *Promoting Expanded Opportunities for Radio Experimentation and Market Trials under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, Notice of Proposed Rulemaking, ET Docket No. 10-236 (released November 30, 2010) (*"NPRM"*).

[3] Referred to as "V-COMM Comments" in this report.

[4] *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, Notice of Inquiry, ET Docket No. 10-237 (released November 30, 2010) (*"NOI"*).

[5] V-COMM's NOI Comments was submitted as an attachment to Verizon Wireless' comments on February 10, 2011, and V-COMM's NOI Reply Comments was submitted separately on March 28, 2011.

[6] V-COMM has conducted extensive compatibility and interference studies within AT&T Wireless' and Verizon Wireless' networks including interference testing of spectrum-sharing technologies and trials within CMRS spectrum.

studies in CMRS spectrum bands,[7] and participated in numerous FCC proceedings with comprehensive engineering reports.[8]

For reasons provided herein, the expanded opportunities as proposed in the NPRM for radio experimentation and market trials should not be authorized to third parties in licensed CMRS spectrum. CMRS spectrum bands are intensely utilized, have highly mobile users, and are not suitable for radio experimentation and market trials which would result in harmful interference to existing CMRS services. In addition, CMRS bands provide critical Public Safety, E911 and other emergency services that must be fully protected from harmful interference.

CMRS licensees have limited engineering staff that are not capable of investigating and addressing third party experiments in their licensed bands. Such a distraction will diminish the quality of service of CMRS networks and slow the rate of innovation of new CMRS technologies including LTE.[9] The Commission should consider other bands more suitable for researching, testing, and developing new and unproven technologies as we provided in our comments,[10] which will not interfere with existing licensed services.

As addressed herein, neither party – the experimental applicant nor the licensed incumbent – has sufficient information on their own to make an adequate determination as to the extent of harmful interference that will occur to incumbent licenses services, and thus any

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[7] V-COMM has conducted spectrum noise and interference measurements within Verizon Wireless and AT&T Wireless' CMRS networks. V-COMM submitted the "AMPS Noise Floor Study" within the FCC's AirCell spectrum-sharing proceeding (ET 02-86) on April 10, 2003, and the "PCS Noise Floor Study" within the FCC's Spectrum Policy Task Force Report proceeding (ET 02-135) on Sept. 16, 2003. These spectrum noise studies were also provided as Attachment B and Attachment C to Comments filed by V-COMM in the FCC's Interference Temperature (ET 03-237) comment proceeding on April 5, 2004.

[8] V-COMM has participated in numerous FCC proceedings with comprehensive engineering reports including experimental AirCell, Cellular Airborne, Spectrum Policy Task Force, Ultra-wide band, Interference Temperature, Cognitive Radio, PCS H-Block, AWS-III Block, and Low Power Auxiliary Stations, Wireless Microphones in 698-806 MHz band proceedings.

[9] LTE (Long Term Evolution) is a 4th generation wireless technology that is being deployed by wireless operators and under continued development with new releases and enhanced functionality.

authorizations for experimental licenses in CMRS spectrum would essentially become a responsibility of both parties to ensure incumbent license services are protected from harmful interference. Further, many parties commenting stated that coordination, notification and most importantly consent of CMRS licensees operating on co-channel, adjacent bands and adjacent markets should be required for all radio experimental licenses and testing activities by universities, research organizations, and health care facilities.

In addition, we address herein that the Commission's current experimental licensing rules work very well and are not an impediment to innovation, and that power flux density thresholds and Part 15 limits will not provide sufficient protection from harmful interference for CMRS services in CMRS bands.

Lastly, experiments performed inside anechoic chambers and faraday cages should not require experimental licenses, however open area test sites should continue to require them. FCC rules should require sufficient shielding and isolation to prevent signals leaking outside these facilities and causing harmful interference to existing services in licensed spectrum bands.

II. LICENSED CMRS SPECTRUM IS INTENSIVELY UTILIZED AND ILL-SUITED FOR CONDUCTING UNPROVEN EXPERIMENTS

As addressed in V-COMM Comments, the expanded opportunities proposed in the NPRM for radio experimentation and market trials in licensed CMRS spectrum should not be authorized to third parties. Licensed CMRS spectrum is not suitable and not compatible with third party experimental uses. Therefore universities, research organizations, and health care facilities should not utilize licensed CMRS spectrum to conduct unproven radio experiments or market trials. Further, CMRS bands provide critical Public Safety, E911 and other emergency

[10] V-COMM Comments at 11-12.

services that must be protected from harmful interference. Several parties including Cisco,[11] AT&T,[12] and V-COMM[13] noted that CMRS bands provide critical Public Safety, E911 and other emergency services that must be fully protected from harmful interference.

Universities, research organizations, and health care facilities should not utilize licensed CMRS spectrum to conduct unproven radio experiments, which can result in harmful interference to incumbent CMRS services. CMRS spectrum is intensely utilized, has highly mobile users, ubiquitous coverage, continuously changing network technologies, and is very sensitive to external system interference. Many parties indicated in the FCC's Dynamic Spectrum NOI proceeding including CTIA,[14] AT&T,[15] PSIC,[16] and Microsoft [17] that CMRS spectrum bands are intensively utilized and least suitable for third party uses. Thus, licensed CMRS spectrum bands are not suitable for radio experimentation or underlay spectrum sharing technologies, which would result in harmful interference to existing and future CMRS services.

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[11] Cisco Comments at 4. "Bands used for the provision of commercial mobile services, public safety spectrum, emergency or public safety systems on the institution's grounds require special protections."

[12] AT&T Comments at 5. "Specifically, the Commission concludes that "experiments on bands assigned to mobile service providers (e.g., the Cellular Radiotelephone Service, broadband PCS, AWS, 700 MHz) could have the potential to disrupt mobile telephone use on campus—at a minimum inconveniencing one of the most active and engaged mobile device user communities, and at worst, impeding the ability to reach 911 or receive campus-wide emergency text alerts."

[13] V-COMM Comments at 3, 12.

[14] CTIA's NOI Comments at 4-5, CTIA commented that time and time again they have demonstrated that U.S. mobile wireless providers are the most efficient users of spectrum worldwide, and pack more subscribers into each megahertz of spectrum than the mobile providers of any other nation.

[15] AT&T's NOI Comments at i, CMRS bands are the "most heavily and efficiently used spectrum bands in the U.S., and are relied upon by public safety, utilities, the medical industry, and hundreds of millions of U.S. consumers" and third party "dynamic spectrum use technologies are technically unsuited for the licensed mobile bands, which are constantly changing and are characterized by an extremely large number of low power transmitters and sensitive receivers with unpredictable usage patterns,"

[16] Public Interest Spectrum Coalition's (PISC) NOI Comments at 28, "At the outset, PISC reiterates its contention that frequency bands that are intensively and efficiently in use – such as the bands used for CMRS – are the least suitable candidates for spectrum band sharing".

[17] Microsoft's NOI Comments at 2, "Notably, because Commercial Mobile Radio Service (CMRS) providers intensively use their spectrum, mandated access by smart radios would not be appropriate in spectrum bands licensed for their exclusive use."

Moreover, CMRS networks and technologies are not compatible with third party uses sharing licensed CMRS spectrum, which will result in harmful interference and lower quality CMRS services. CMRS networks and services will be affected by third party radio experiments conducted within its licensed spectrum bands. CMRS networks can experience losses in system capacity, reduced data throughputs, disruptions, and poor quality of service when third party experiments increase noise and interference levels within licensed CMRS spectrum.

In addition, CMRS licensees have limited engineering staff that are not capable of investigating and addressing third party experiments in their licensed bands. Such a distraction will diminish the quality of service of CMRS networks and slow the rate of innovation of new CMRS technologies.[18] This would divert the engineering staff of CMRS network operators and manufacturers in their efforts to provide high quality CMRS service, operate, maintain and optimize their networks and spectrum efficiency, and advance new technologies like LTE.[19] Thus, the Commission should consider other bands more suitable for researching, testing, and developing new and unproven technologies, which will not interfere with existing licensed CMRS services.[20]

III. CURRENT FCC RULES FOR EXPERIMENTAL LICENSES WORK WELL AND ARE NOT AN IMPEDIMENT TO INNOVATION

A few parties reminded the Commission that its current experimental licensing rules work very well and are not an impediment to innovation. For example, Motorola Solutions, Inc. (MSI) commented that the current "process has developed well over the years and is now a

[18] V-COMM Comments at 17-18.

[19] LTE (Long Term Evolution) is a 4th generation wireless technology that is being deployed by wireless operators and under continued development with new releases and enhanced functionality.

[20] Instead, other more suitable bands should be considered for such third party radio experimentation and market trials as we noted in Section III of V-COMM Comments.

model of efficiency among FCC licensing programs ... the current process works very well today".[21] Further, MSI believes that the Commission should maintain its current experimental polices and that "[s]uch an approach is good engineering practice that MSI has followed for years".[22] Marcus Spectrum Solutions also noted that the current FCC experimental licensing rules are not an impediment to innovation:

> "While the online filing systems for Part 5 licenses are awkward and dated, in general the Part 5 system works very well and is not a major impediment to innovation. When the Spectrum Policy Task Force specifically asked for comments on the experimental licensing system and possible improvements in Docket 02-135, it received **virtually no input** – at that time it was clear that Part 5 licenses were not a major problem area. We believe that the general conclusion of the UEWG in 2002 is equally valid today." [23]

> "the present Part 5 Experimental License System is not a major obstacle to innovation and given the expected tightening of resources at FCC due to the budget situation it is questionable whether the proposals here have really significant enough impact on innovation to justify the diversion of staff effort from larger impact issues such as the more general Wireless Innovation NOI." [24]

Further, Marcus Spectrum Solutions comments that the issue of NTIA coordination and transparency on federal spectrum appears to the roadblock to innovation and remains the "elephant in the room" in experimental licensing since the majority of spectrum is either federal government spectrum or shared spectrum subject to such coordination.[25] And, Marcus Spectrum Solutions believes that improving the present OET Experimental Licensing Filing System would be a better "bang per buck",[26] stating that "[a] total overhaul of the dated and obsolescent OET

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[21] Motorola Solutions, Inc. (MSI) Comments at 1 (emphasis added).

[22] Id. at 4.

[23] Marcus Spectrum Solutions Comments at 5.

[24] Id. at 1-2.

[25] Id. at 2. Also, Marcus Spectrum Solutions Comments at 8-10, notes that 57% of spectrum in the range of 300 MHz to 3 GHz requires NTIA approval and such cases are generally classified. In addition, as noted in its Appendix at 3-5, from the experimental license section of the FCC's SPTF Report 2002, Ericsson & Motorola comments in the SPTF report cite similar concerns.

[26] Id. at 3.

Experimental Licensing System Electronic Filing System would be very helpful and would lower barriers to experimentation." [27]

In fact, V-COMM recognizes that CMRS licensees have been successful in advancing new technologies into their spectrum bands for the past 30 years for the benefit of wireless consumers representing 93% of the nation, which include 1st generation through 4th generation wireless technologies that continue to be advanced.[28] These advances in innovation and technologies were successful in CMRS spectrum within the current FCC experimental license rules. Therefore, the record and history demonstrates that the current FCC experimental licensing rules are not an impediment to innovation in CMRS spectrum bands.

Overall, the existing Part 5 experimental licensing system works well and does not inhibit innovation. Boeing was the only party commenting in the proceeding that cited difficulty obtaining licensee consent for experimental license testing. Boeing cited coordination issues with CMRS licensees when requesting to perform High Intensity Radiated Field (HIRF) aircraft testing in licensed CMRS bands.[29] However, in its comments, Boeing did not detail the extent of the high radio intensity levels that were requested or whether they were willing to perform such tests in off-hours or in other locations (i.e. remote areas without CMRS service, etc.) that may have less potential for interference to existing licensed CMRS services.[30] Therefore, its uncertain whether consent was unreasonably withheld in this case, or was due to the high power levels Boeing was requesting that would cause harmful interference to local CMRS operations.

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[27] Id. at 14.

[28] Id. at 17-18.

[29] Boeing Comments at 13. Also, see footnote 34, citing *Boeing Wireless NOI Comments*, at 10-12 (describing Boeing's difficulty in coordinating consent with wireless service licensees to enable High Intensity Radiated Field testing of new aircraft).

[30] We also note that there are test facilities that provide such FAA compliant HIRF RTCA/DO 160-F testing, which can be completed on components within anechoic chambers pursuant to FAA rules.

In general, however, experimental licenses have been successful in coordinating and receiving consent from licensees to conduct experiments in licensed spectrum.[31] Therefore, we agree with Marcus Spectrum Solutions and Motorola that the current experimental licensing system works very well and is not an impediment to innovation.

IV. COORDINATION AND CONSENT IS REQUIRED FOR EXPERIMENTAL LICENSES

University, research and health care experimental licenses should be grouped together within FCC rules, and have the same regulations apply to each of them, as they represent the same issues that can impact incumbent spectrum licensees and users. Whether the experimental license is for research, health care or even commercial purposes is irrelevant with regard to the potential for interference. Accordingly, we address them all collectively as a group in this section.

Coordination and Consent Requirements. Experimental licenses must provide detailed coordination information and obtain prior consent from CMRS licensees before any experiments are performed in licensed CMRS spectrum to ensure that harmful interference will not occur to existing CMRS services. Further, experimental licenses must coordinate with and obtain prior consent on an ongoing basis from the incumbent licensees to account for the frequent changes in CMRS networks. And, given that CMRS licensees are protected from harmful interference, obtaining consent of the licensee is required prior to performing any experiments in licensed CMRS spectrum.

Many parties commented on the importance of the coordination and consent requirements with regard to the expanded experimental licensing program proposed in the NPRM. We further

[31] Lockheed Martin Comments at 3, Lockheed confirmed most incumbents "are willing to accommodate coordination requests, and most coordinations are concluded without incident."

note that the prevention of interference essentially become a shared responsibility of both parties, the experimental applicant and the incumbent licensee, in order to ensure that incumbent licensed services are protected from harmful interference. Therefore, the experimental applicant must obtain consent from the incumbent licensee.

In fact, the experimental researcher does not have enough information on the incumbent licensed systems, technologies, and use of spectrum to determine if harmful interference would occur. And, due to the lack of understanding of specific spectrum uses, the interference could be bi-directional affecting both the incumbent licensee's system and the experimenter's research, which runs counter-productive to testing and evaluating any new experimental technologies. Also, without sufficient coordination, the CMRS incumbent does not have enough information about the radio equipment and specific plans of the experimental research tests to determine the extent (i.e. the locations, the times, the impacted to its users) of the harmful interference that would occur to its network. Furthermore, CMRS networks are constantly upgrading technologies, re-configuring and optimizing systems, deploying new base stations, repeaters, picocells and other technologies within their networks, which represents a constant state of flux for its system operation and use of spectrum. Thus, ongoing coordination and ongoing consent is required for any experimental testing in CMRS spectrum in order to ensure that the essential CMRS services are not jeopardized.

The experimental researcher cannot conclusively determine the extent of harmful interference that would occur to incumbent CMRS services because they are unaware of the incumbent's detailed system information and spectrum uses. Thus, they must coordinate and obtain consent from the incumbent licensees. CMRS licensees frequently update and simultaneously operate a mix wireless technologies such as CDMA 1xRTT, EVDO, GSM, EDGE, UMTS, HSPA, and/or LTE technologies in their CMRS bands to meet market objectives.

In many cases, each technology has different interference requirements, bandwidths, frequencies, and operating signal levels. The frequency plan, spectrum use, and technology used will also change over time to meet market requirements. The experimental research applicant could not possibly obtain proprietary CMRS system information, operating network radio frequency parameters, technologies, and other detailed system information because it is proprietary information and constantly changing on a daily basis. Further, CMRS licenses are constantly upgrading technologies, site locations, in-building repeater and coverage equipment, tower locations and network changes. The experimental research applicant could not definitively assess the interference implications without coordinating and obtaining consent of the CMRS licensee.

In a similar regard, the incumbent licensee does not have sufficient information about the radio equipment and specific plans of the experimental research tests to determine the extent that harmful interference would occur to its network. Experimental research technologies and equipment are not always well defined, may not be FCC type certified, and will generally not be compliant to specific wireless standards.[32] In some cases the testing may either contain classified, sensitive or proprietary material which may not be completely shared. The research location, power, bandwidth, emissions, and specific test plan need to be coordinated and consented with the incumbent CMRS licensee to ensure the protection of the incumbent licensee's communications services. In most cases, the only practical way to conduct experiments in licensed CMRS spectrum would be to perform experiments in off-hours and on

[32] Wireless standards are developed and documented for engineers to understand the operation of specific wireless technologies and the compatibility issues associated with those technologies with other known technologies. Since experiments by their nature will involve new and unproven technologies there would be unknown consequences with respect to the compatibility of operating them with current systems.

specific channels taken out of service to ensure protection of CMRS operations, which is the process that CMRS licensees use to test new technologies in their networks.

The Satellite Industry Association (SIA) also opposes experimental license coordination that places the interference burden on the incumbent licensees:

> "The Commission declined to propose imposing specific coordination obligations on program experimental licensees and, in lieu of coordination, proposed that a web-based registration be completed at least seven calendar days prior to commencement of any experiment. Under the proposal, service licensees would be responsible for monitoring the registration and raising interference concerns with the program licensee applicant within the seven-day period. The service licensee would also bear the burden of proving that a proposed experiment would cause harmful interference. SIA *opposes* the *Commission's approach because it turns the notion of spectrum priority on its head*. By requiring service licensees to monitor databases continually for potentially-interfering experiments and then prove the existence of such interference, the web-based registration proposal inappropriately shifts the burden of policing compliance with the Commission's interference-avoidance requirements to parties with superior spectrum rights." [33]

Moreover, it's not possible for CMRS licensees to support many wide-scale experiments in its licensed spectrum because they do not have the engineering resources to evaluate and monitor each of the experiments that would be very time consuming to ensure that such third-party spectrum uses do not interfere with providing high quality CMRS service. The Commission cannot divert the limited engineering resources of CMRS network providers to investigating and addressing unproven radio experiments in licensed CMRS spectrum. CMRS engineering staff are required to support the daily operation, maintenance, and optimization of the CMRS network to provide high quality services to its customers, and cannot support other third-party initiatives operating in the same spectrum bands.

Notification Requirement. Experiments conducted with licensee consent will need to provide proper coordination and sufficient notification to CMRS licensees. CMRS operators would need to review the details of the experiment and radio equipment utilized along with their

[33] Satellite Industry Association Comments at 11-12 (emphasis added).

incumbent uses of spectrum in the specific test areas with the licensee's engineering resources and with its vendor's engineering resources as well in some cases. Sufficient notification time is required to complete these tasks to ensure harmful interference would not occur to existing CMRS services. Therefore, the notification period for CMRS licensees needs to be open ended.

In some cases (i.e. for relatively limited experiments requested for off-hours testing) the notification, coordination and consent can be completed within 30 days. However, for other cases such tasks will generally require longer periods of time and may become an iterative process to clarify and fully understanding the requested testing experiments, to possibly revise specific testing plans, and to avoid interference to local CMRS operations. In addition, with any new technology experiments in licensed CMRS spectrum there would be unknowns with respect to the compatibility of such technologies with existing CMRS systems, and the testing process may need to be incremental to immediately address any instances of interference and to revise the test plans to ensure interference is avoided to CMRS networks. Accordingly, the coordination and consent needs to be ongoing and iterative for experiments conducted in licensed CMRS spectrum.

Consequently, we disagree with a few commenting parties and as initially proposed in the NPRM that a seven day notification period is acceptable for all cases. CTIA notes that "thirty days is the *minimum time* necessary for engineering personnel from affected CMRS licensees (and their vendors) to review the detailed plans and technical specifics, ensure that they will not pose an interference risk to existing or planned CMRS operations, and then notify the Commission and the applicant of any concerns." [34] However, as we outlined above, 30 days notification will not be sufficient time in most cases. Further, as provided in V-COMM's comments, we noted the importance of coordinating with adjacent markets and adjacent bands,

"experiments conducted on adjacent bands and adjacent markets should provide advance notice to CMRS licensees of a minimum of 30 days. Longer notification periods may be required depending on the nature of the planned testing activities, to understand the testing activities and assess the impact to the CMRS network, to resolve any test activities that can cause interference to CMRS services, and in cases that require the CMRS equipment manufacturer to be consulted for questions and compatibility issues."[35]

Incumbent Licensee Consent. Most of the commenting parties identified incumbent licensee consent and protection from interference as paramount requirements for experimental licenses. We agree with the CTIA's comments that "It is critical, however, that the Commission adopt appropriate safeguards and interference protections (especially for incumbent commercial mobile radio service ("CMRS") operations) to ensure that the additional experimentation does not harm consumers or undermine wireless investment, innovation, and efficient spectrum use."[36] Motorola also states that "protecting licensees from interference" is a main principal to safeguard.[37] Qualcomm concurs on providing incumbent protection by stating, "all testing conducted under the new ERS regulatory framework needs to provide full protection to authorized operations." [38] The Satellite Industry Association (SIA) writes that the Commission must "ensure that the newly flexible regime does not result in an unacceptable risk of harmful interference to existing service licensees." [39]

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[34] CTIA Comments at 6 (emphasis added).

[35] V-COMM Comments at 7.

[36] CTIA Comments at 2.

[37] Motorola Solutions Comments at 2.

[38] Qualcomm Comments at 3.

[39] Satellite Industry Association Comments at 1.

Many parties contend that coordination and consent of CMRS licensees operating on co-channel, adjacent bands and adjacent markets must be required for experimental licenses and any testing activities by universities, research organizations, and health care facilities. APCO states the experimental applicant "should be required to specifically notify licensees in affected bands and obtain prior concurrence." [40] AT&T states that "before adopting any proposals, however, the Commission should modify the proposed rules to better protect existing CMRS networks and subscribers…Failure to require notice and consent would expose CMRS networks and consumers to harmful interference, delay the detection of the source, and impede its rapid resolution." CTIA asserts that "the Commission should require an affected CMRS licensee's prior approval to a test or experiment." Lastly, the Wireless Communications Association International ("WCAI") says "The Commission should require that an applicant for a program experimental radio license obtain the consent of existing licensees before the applicant begins its experiment." [41] The TIA also urges the Commission "to ensure that adequate protection is afforded to primary and secondary licensees. The Commission should avoid transferring the burden of interference notification and detection to allocated frequency licensees, and TIA opposes rule changes that will result in such a shift." [42]

Thus it is critical for the experimental licenses to properly coordinate and obtain prior consent from the incumbent CMRS licensees for each experiment to prevent interference to CMRS services. For reasons provided above and in our comments, the expanded opportunities as proposed in the NPRM for radio experimentation and market trials should not be authorized to third parties in licensed CMRS spectrum without licensee consent.

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[40] APCO Comments at 3.

[41] WCAI Comments at 1.

[42] TIA Comments at 3.

V. POWER FLUX DENSITY THRESHOLDS AND PART 15 LIMITS WILL NOT PROTECT CMRS SERVICES FROM HARMFUL INTERFERENCE

As provided in V-COMM's comments, in response to the NPRM's request for comments on establishing power flux densities (PFD) to facilitate radio experiments,[43] the Commission cannot set a power flux density threshold in CMRS spectrum as any level would result in an increase in noise and interference levels from third party experiments in CMRS spectrum and cause harmful interfere to CMRS and E911 services.[44] CMRS systems operate at very low signal and noise levels to optimize CMRS spectrum utilization and efficiency. Further, E911 calls require reception of multiple signals at very low levels for the CMRS system to be able to make location determinations, which is required for Public Safety call centers to accurately locate distressed E911 callers.[45] Given this, CMRS technologies are very sensitive to external system noise and interference and there are no additional noise and interference levels that are acceptable. Therefore, there is no threshold for PFD that will protect incumbent CMRS and public safety E911 services.

Wireless Communications Association International ("WCAI") also points out that instead of attempting to establish PFD thresholds for all frequency bands and services, the Commission should rely on existing licensee consent to establish permissible experimental operations:

> "Relying on the consent of existing licensees would also obviate the need to establish a maximum measured power flux density (pfd) limit to ensure that PERL experiments do not extend beyond the boundaries of a PERL applicant's property. The number of frequency bands and services potentially affected by the Commission's proposal would

[43] NPRM at ¶ 22.

[44] V-COMM Comments at 10-11.

[45] This is referenced to network based time-difference-of-arrival (TDOA) and handset based E911 location systems that are used in CMRS systems today. These systems rely on very low level signals for location determination, which include signals that are lower level than those used to maintain the voice and data communications.

> make the establishment of pfd limits by rule extraordinarily difficult. For a number of reasons, some services are more likely to suffer harmful interference from experimental radio use than others. This reality of physics means the Commission would either need to establish a relatively low overall pfd limit or establish separate pfd limits for various bands and services. Either approach would likely result in a suboptimal outcome. A restrictive pfd limit may unnecessarily limit the utility of PERL experiments in some cases, and separate pfd limits would be difficult to develop and complicated to apply. If the Commission instead relies on a consent-based approach, PERL applicants and licensees could tailor pfd limits to optimize the value of the experiment while avoiding the potential for harmful interference." [46]

V-COMM agrees that requiring existing licensee consent is the best and only alternative for conducting experiments in licensed CMRS bands.

Some parties commented that radio experiments operating at or below the maximum power levels for unlicensed Part 15 unintentional radiators should not require an experimental license for operation at any location,[47] and some parties proposed them for indoor demonstrations at trade shows.[48] Cisco adds that coordination with licensees is required for trade show demonstrations in its comments, "the manufacturer should be required to coordinate the frequencies to be used with existing licensees." [49]

However, V-COMM disagrees with comments that Part 15 radiation limits can serve as permissible emissions thresholds because such emission levels will not provide sufficient protection from interference on all frequency bands in all cases, such as in CMRS and Public Safety bands.[50] Further, emissions operating at Part 15 limits are strong enough to cause harmful interference to CMRS and Public Safety services in various spectrum bands. For example, Part 15 limits permit the receive levels of -79 dBm/MHz at 800 MHz, and -89 dBm/MHz at 1950

[46] WCAI Comments at 5-6.

[47] TIA Comments at 7, Lockheed Martin Comments at 6.

[48] Cisco Comments at 6, SIA Comments at 6.

[49] Cisco Comments at 6.

[50] We also note that FCC Part 15 limits are not appropriate as they are used for unintentional emissions, and not for the intended signal to be transmitted at Part 15 limits on a continuous basis. Normally, Part 15 compliant devices operate at levels significantly below these limits.

MHz.[51] Indoor and nearby CMRS and Public Safety services can operate at much lower levels than these Part 15 levels and result in harmful interference CMRS and Public Safety services. Therefore, emissions operating at Part 15 limits will not sufficiently protect CMRS and Public Safety services, and should not be used as a permissible limit for experiments in any locations without the consent of existing licensees.

In addition, many parties commented that experimental licenses must utilize the minimum power necessary and be restricted to the smallest practicable area needed to accomplish the experiments.[52] V-COMM agrees that experiments must utilize the minimum power necessary and restricted to smallest practical area to accomplish the objectives of the experiments. Further, utilization of indoor locations, non-mobile applications, and off-hours should be employed for the experiments to reduce the range and risk of interference to incumbent licensed services.[53] Furthermore, transmissions at any power levels used in experiments within licensed spectrum must be coordinated with and consented by the incumbent licensee to ensure that harmful interference will not occur to incumbent services.

VI. ANECHOIC CHAMBERS, FARADAY CAGES AND OPEN AREA TEST SITES

Parties submitting comments in the NPRM proceeding on these issues agree that radio experiments performed inside anechoic chambers and faraday cages should not require experimental licenses, while radio experiments performed at open area test sites should continue

[51] Pursuant to FCC Part 15.109 limits for unintentional radiators at a distance of 3 meters 200 uV/m and 500 uV/m limits are permitted within the measurement bandwidths of 100 kHz and 1 MHz for frequencies below and above 960 MHz, respectively. Receive levels provided in dBm/MHz reference isotropic antenna levels. The 800 MHz and 1950 MHz frequencies are representative of CMRS Cellular, Land Mobile Radio (LMR), and PCS bands.

[52] AT&T Comments at 8, Cisco Comments at 3, BAE Systems Comments at 9.

[53] CTIA Comments at 6, "conducted during off-peak usage hours whenever possible"; AT&T Comments at 7, " experiments should be confined to set locations and not made mobile."

to require experimental licenses to operate in licensed spectrum bands as noted below. Further, V-COMM states in its comments that sufficient RF shielding should be maintained and required to prevent signals from leaking outside such test facilities, which can cause harmful interference to existing services in licensed spectrum bands.[54]

Anechoic Chambers and Faraday Cages. Many parties stated that the Commission should codify its long-standing policy of permitting radio experiments performed inside anechoic chambers and faraday cages and should not require experimental licenses due to the RF isolation and shielding provided by these types of facilities.[55]

As previously noted in V-COMM Comments, the Commission should require sufficient isolation and shielding effectiveness be maintained to prevent signals from leaking outside such facilities, which can cause harmful interference to existing services in licensed spectrum bands such as CMRS bands. The Satellite Industry Association (SIA) also supports this provision that "any unlicensed RF testing conducted within an anechoic chamber or Faraday cage should be sufficiently shielded." [56] V-COMM adds that shielding effectiveness and signal leakage measurements should be performed on all frequency bands and power levels utilized to confirm the test facility and test equipment are operating properly and accordingly to manufacturer's specifications.[57] Boeing also commented that "entities should be able to continue to employ self-certification procedures to ensure that their test operations will not cause interference to authorized radio communications ... Boeing conducts an initial self-certification of each RF

[54] V-COMM Comments at 19-20.

[55] Boeing at 16-17, BAE Systems at 27, EIBASS at 15, Hewlett Packard at 3, Qualcomm at 10, Satellite Industry Association at iii, Lockheed Martin at 5.

[56] SIA Comments at 5.

[57] Anechoic chambers must be commercial grade and designed for high isolation test purposes to qualify for testing without experimental licenses. Similarly, any faraday cages utilized must have equivalent isolation performance of commercial grade anechoic chambers.

enclosure and periodically conducts follow up tests to verify continued compliance with its non-interference standards." [58]

Further, Boeing suggests that the "Commission should impose frequency-specific maximum emissions limits for the facilities as measured outside the facilities,"[59] while Lockheed Martin suggests that the "Commission should not, however, mandate compliance with a specific standard for shielding ... the entities conducting such experiments are still required to ensure that they operate on a non-interfering basis." [60] Specifically, Boeing and SIA proposed adopting the FCC's Part 15 limits for unintentional radiators as a standard for maximum permitted emissions outside these facilities.[61] V-COMM disagrees with Boeing and SIA on adoption of Part 15 radiation limits as a permissible standard because such emission levels will not provide sufficient protection for all frequency bands in all cases, such as in CMRS and Public Safety bands.[62] V-COMM maintains that no specific standard can be applied that would protect incumbent services on all frequency bands, and therefore the Commission must rely on licensee consent to ensure protection of incumbent services.

Further, emissions at Part 15 limits are strong enough to cause harmful interference to CMRS and Public Safety services in various spectrum bands. For example, Part 15 limits permit the receive levels of -79 dBm/MHz at 800 MHz, and -89 dBm/MHz at 1950 MHz.[63] Indoor and

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[58] Boeing Comments at 20.

[59] Boeing Comments at 16.

[60] Lockheed Martin Comments at 5.

[61] Boeing Comments at 18-19, SIA Comments at 5-6.

[62] We also note that FCC Part 15 limits are not appropriate as they are used for unintentional emissions, and not for the intended signal to be transmitted at Part 15 limits on a continuous basis. Normally, Part 15 compliant devices operate at levels significantly below these limits.

[63] Pursuant to FCC Part 15.109 limits for unintentional radiators at a distance of 3 meters 200 uV/m and 500 uV/m limits are permitted within the measurement bandwidths of 100 kHz and 1 MHz for frequencies below and above 960 MHz, respectively. Receive levels provided in dBm/MHz reference

nearby CMRS and Public Safety services can operate at much lower levels than these Part 15 levels and result in harmful interference CMRS and Public Safety services. Therefore, emissions operating at Part 15 limits will not sufficiently protect CMRS and Public Safety services, and should not be used as a permissible limit for compliance of anechoic chambers and faraday cages. Further, properly installed and operating anechoic chambers and faraday cages should reduce emissions outside the facilities to well below the Part 15 permissible limits.

Open Area Test Sites (OATS). A few parties commented on OATS in the NPRM comment proceeding including V-COMM and the Engineers for the Integrity of Broadcast Auxiliary Services Spectrum (EIBASS). The parties stated that radio experiments performed at OATS should continue to require experimental licenses to operate in licensed spectrum bands. EIBASS also noted that licensing for OATS is important for tracking and interference resolution purposes. Therefore, OATS should remain as requiring an experimental license. EIBASS notes:

> "Because such sites by definition are not screened or shielded, OATs should always require an FCC license; this could be an experimental license, a Manufacturer's Radio Service (MRS) license, or other Commission authorization. But an OAT facility should always have an authorization record in an FCC database and resultant accountability in the event that harmful interference is caused to any licensed service. Since an OAT facility generally requires a substantial investment in land, structures and hardware, requiring the licensing of such a site in all cases would represent a small and reasonable burden." [64]

V-COMM agrees that such facilities should require experimental licenses, and we add that they should be required to confirm that signals are not leaking outside the test facilities where it could interfere with existing licensed services. Signal leakage measurements should be performed on all frequency bands and power levels utilized in tests. Further, V-COMM notes

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isotropic antenna levels. The 800 MHz and 1950 MHz frequencies are representative of CMRS Cellular, Land Mobile Radio (LMR), and PCS bands.

[64] EIBASS Comments at15.

additional information and requirements that should be required for OATS experimental license applications:

> "Applications for OATS experimental licenses should include a detailed description of the test site facility, the power and frequency bands utilized in tests, the types of antenna used in tests, radio frequency techniques used to minimize signal reflections and leakage from the facility, proof of non-interference to existing licensed services, and justifications for not using anechoic chambers for such experiments. Construction of such facilities require sufficiently open areas free of reflections, an advanced competence in radio frequency engineering, and should meet qualifications described in ANSI C63 standards for open area test sites." [65]

VII. CONCLUSION

For reasons provided, the Commission should not authorize Experimental Licenses or Market Trials to third parties in licensed CMRS spectrum. CMRS spectrum bands are not suitable and not compatible with third party radio experiments by universities, research organizations, and health care facilities. CMRS spectrum bands are intensely utilized and have high mobility users that are not suitable for radio experimentation or underlay spectrum sharing, which would result in harmful interference to existing CMRS services including E911 and other emergency services. The Commission should consider other bands more suitable for research, testing, and developing new and unproven technologies, which will not interfere with existing licensed services.

Further, CMRS licensees have limited engineering staff that are not capable of investigating and addressing third party experiments in their licensed bands. Such a distraction will diminish the quality of service of CMRS networks and slow the rate of innovation of new CMRS technologies including LTE.

[65] V-COMM Comments at 20. OATS facilities are generally confined areas that are designed to be radio frequency isolated from surrounded areas with minimized reflections.

In addition, we note that the Commission's current experimental licensing rules work very well and are not an impediment to innovation, coordination and consent must be required for any experiments in licensed spectrum, and power flux density thresholds and Part 15 limits will not provide sufficient protection from harmful interference for CMRS services and should not be adopted for experimental licenses absent licensee consent.

Respectfully Submitted,

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APPENDIX A – COMPANY INFORMATION & BIOGRAPHIES

V-COMM is a leading provider of quality engineering and engineering consulting services to the worldwide wireless telecommunications industry with offices in Cranbury, NJ and Blue Bell, PA. V-COMM's engineering staff is experienced in Cellular, Personal Communications Services, 700 MHz Spectrum, Wireless Broadband Data, Enhanced Specialized Mobile Radio, Paging, Public Safety, 2-Way radio, Microwave, and Broadcast Mobile TV. We have provided our expertise to wireless operators in engineering, system design, implementation, performance, optimization, and evaluation of new wireless technologies. We have extensive experience in studying interference in various spectrum bands including Cellular, SMR, PCS, AWS, Air-to-ground, Public Safety, and 700 MHz spectrum. We have engineering experience in all commercial wireless technologies, including LTE, HSPA, UMTS, EVDO, CDMA, GSM, EDGE, WiMAX, MediaFLO, DVB-H, and Public Safety wireless technologies including analog and digital Project 25, EDACS, Opensky, and other trunking and conventional radio networks. Further, V-COMM was selected by the FCC & Department of Justice to provide expert analysis and testimony in the Nextwave and Pocket Communications Bankruptcy cases. For additional information, visit V-COMM's web site at www.vcomm-eng.com.

BIOGRAPHIES OF SENIOR MEMBERS OF ENGINEERING STAFF

Dominic C. Villecco
President and Founder, V-COMM, L.L.C.

Dominic Villecco, President and founder of V-COMM, is a pioneer in wireless telecommunications engineering, with over 29 years of executive-level experience and various engineering management positions previously held. Under his leadership, V-COMM has grown from a start-up venture in 1995 to a highly respected full-service wireless telecommunications engineering firm.

In managing V-COMM's growth, Mr. Villecco has overseen expansion of the company's portfolio of consulting services, which today include a full range of RF and Network support, network design tools, measurement hardware, and database services as well as time-critical engineering-related services such as business planning, zoning hearing expert witness testimony, regulatory advisory assistance, and project management.

Before forming V-COMM, Mr. Villecco spent 10 years with Comcast Corporation, where he held management positions of increasing responsibility, his last being Vice President of Wireless Engineering for Comcast International Holdings, Inc. Focusing on the international marketplace,

Mr. Villecco helped develop various technical and business requirements for directing Comcast's worldwide wireless venture utilizing current and emerging technologies.

Previously he was Vice President of Engineering and Operations for Comcast Cellular Communications, Inc. His responsibilities included overall system design, construction and operation, capital and operating budget preparation and execution, interconnection negotiations, vendor contract negotiations, major account interface, new product implementation, and cellular market acquisition. Following Comcast's acquisition, Mr. Villecco successfully merged the two departments and managed the combined department of 140 engineers and support personnel.

Mr. Villecco served as Director of Engineering for American Cellular Network Corporation (AMCELL), where he managed all system implementation and engineering design issues. He was responsible for activating the first cellular system in the world utilizing proprietary automatic call delivery software between independent carriers in Wilmington, Delaware. He also had responsibility for filing all FCC and FAA applications for AMCELL.

Prior to joining AMCELL, Mr. Villecco worked as a staff engineer at Sherman and Beverage (S&B), a broadcast consulting firm. He designed FM radio station broadcasting systems and studio-transmitter link systems, performed AM field studies and interference analysis, and TV interference analysis, and helped build a sophisticated six-tower arrangement for a AM antenna phasing system. He also designed software for FM allocations pursuant to FCC Rules Part 73.

Mr. Villecco started his career in telecommunications engineering as a wireless engineering consultant at Jubon Engineering, where he was responsible for the design of cellular systems, both domestic and international, radio paging systems, microwave radio systems, two-way radio systems, microwave multipoint distribution systems, and simulcast radio link systems, including the drafting of all FCC and FAA applications for these systems.

Mr. Villecco has testified as an expert witness in federal court on behalf of the Department of Justice and the Federal Communications Commission on two separate high profile cases involving wireless system design, implementation and operation.

Mr. Villecco has a BSEE from Drexel University, in Philadelphia. He is also a member of the Drexel ECE (Electrical and Computer Engineering) Department advisory board. In February 2001, Mr. Villecco received the "2001 Distinguished Alumnus Award" from the Drexel ECE Department for his continued contributions to the engineering profession. Since 1983, Mr. Villecco has been an active member of IEEE.

<u>Relevant Expert Witness Testimony Experience:</u>
Over the past fifteen years, Mr. Villecco had been previously qualified and provided expert witness testimony in the states of New Jersey, Pennsylvania, Delaware and Michigan. Mr. Villecco has also provided expert witness testimony in the following cases:

- United States Bankruptcy Court
- NextWave Personal Communications, Inc. vs. Federal Communications Commission **
- Pocket Communications, Inc. vs. Federal Communications Commission **

** In these cases, Mr. Villecco was retained by the FCC and the Department of Justice as a technical expert on their behalf, pertaining to matters of wireless network design, optimization and operation.

David K. Stern
Vice President, V-COMM, L.L.C.

David Stern, Vice President and co-founder of V-COMM, has over 27 years of hands-on operational and business experience in telecommunications engineering. He began his career with Motorola, where he developed an in-depth knowledge of the wireless engineering technologies CDMA, TDMA, and GSM, as well as AMPS and Nextel's iDEN.

While at V-COMM, Mr. Stern oversaw the design and implementation of several major Wireless markets in the Northeast United States, including Omnipoint - New York, Verizon Wireless, Unitel Cellular, Alabama Wireless, PCS One and Conestoga Wireless. He has testified at a number of Zoning and Planning Boards in Pennsylvania, New Jersey and Michigan.

Prior to joining V-COMM, Mr. Stern spent seven years with Comcast Cellular Communications, Inc., where he held several engineering management positions. As Director of Strategic Projects, he was responsible for all technical aspects of Comcast's wireless data business, including implementation of the CDPD Cellular Packet Data network. He also was responsible for bringing into commercial service the Cellular Data Gateway, a circuit switched data solution.

Also, Mr. Stern was the Director of Wireless System Engineering, charged with evaluating new digital technologies, including TDMA and CDMA, for possible adoption. He represented Comcast on several industry committees pertaining to CDMA digital cellular technology and served on the Technology Committee of a wireless company on behalf of Comcast. He helped to direct Comcast's participation in the A- and B-block PCS auctions and won high praise for his recommendations regarding the company's technology deployment in the PCS markets.

At the beginning of his tenure with Comcast, Mr. Stern was Director of Engineering at Comcast, managing a staff of 40 technical personnel. He had overall responsibility for a network that included 250 cell sites, three MTSOs, four Motorola EMX-2500 switches, IS-41 connections, SS-7 interconnection, and a fiber optic and microwave "disaster-resistant" interconnect network.

Mr. Stern began his career at Motorola as a Cellular Systems Engineer, where he developed his skills in RF engineering, frequency planning, and site acquisition activities. His promotion to Program Manager-Northeast for the rapidly growing New York, New Jersey, and Philadelphia markets gave him the responsibility for coordinating all activities and communications with Motorola's cellular infrastructure customers. He directed contract preparations, equipment orders and deliveries, project implementation schedules, and engineering support services.

Mr. Stern earned a BSEE from the University of Illinois, in Urbana, and is a member of IEEE.

Sean Haynberg
Director of RF Technologies, V-COMM, L.L.C.

Sean Haynberg, Director of RF Technologies at V-COMM, has over 21 years of experience in wireless engineering. Mr. Haynberg has extensive experience in wireless system design, implementation, testing and optimization for wireless broadband data and voice systems utilizing UMTS, HSPA, LTE, EVDO, CDMA, GSM, EDGE, ESMR and Analog wireless technologies. In his career, he has conducted numerous new technology deployments, compatibility & interference studies, and evaluations to assess, develop and integrate new technologies that meet industry and FCC guidelines. His career began with Bell Atlantic Mobile, where he developed an in-depth knowledge of wireless engineering.

While at V-COMM, Mr. Haynberg was responsible for the performance of RF engineering team supplying total RF services to a diverse client group. His projects included managing a team of RF Engineers to perform interference testing & analysis, FCC reporting and presentations, studying new wireless technology compatibility and integration with existing CMRS network technologies, conducting technology interference studies at CMRS base stations and customer provided equipment, design, deploy and optimize numerous CMRS wireless networks in various markets, wireless system design & expansion of international markets in Brazil and Bermuda, and development and procurement of hardware and software engineering tools. He has also developed tools and procedures to assist carriers in compliance to FCC rules & regulations for RF Safety, international TV band interference studies, and other FCC regulatory issues. In addition, Mr. Haynberg was instrumental in providing leadership, technical analysis, engineering expertise, and management of a team of RF Engineers to deliver expert engineering support and reporting on behalf of the FCC & Department of Justice, in the NextWave and Pocket Communications Bankruptcy proceedings.

Prior to joining V-COMM, Mr. Haynberg held various management and engineering positions at Bell Atlantic NYNEX Mobile (BANM). He was responsible for evaluating new technologies and providing support for the development, integration and implementation of first office applications (FOA), including CDMA, CDPD, and RF Fingerprinting Technology. Beyond this, Haynberg provided RF engineering guidelines and recommendations to the company's regional network operations, supported the evaluation and integration of new wireless equipment and technologies, including indoor wireless PBX/office systems, phased/narrow-array smart antenna systems, interference and inter-modulation analysis and measurements, and cell site co-location and acceptance procedures. He was responsible for the procurement, development and support of engineering tools for RF and system performance engineers to enhance the performance, design and optimization of the regional cellular networks. He began his career as an RF Engineer responsible for the system design and expansion of cellular markets in New Jersey, Philadelphia, PA; Pittsburgh, PA; Washington, DC; and Baltimore, MD markets.

Mr. Haynberg earned a Bachelor of Science degree in Electrical Engineering with high honors, and attended post-graduate work, at Rutgers University in Piscataway, New Jersey. While at Rutgers, Mr. Haynberg received numerous honors including membership in the National Engineering Honor Societies. In addition, Mr. Haynberg has qualified and provided expert witness testimony in the subject matter of RF engineering and the operation of wireless network systems for many municipalities in the State of New Jersey.

David Hunt
Senior Staff RF Engineer, V-COMM, L.L.C.

Mr. Hunt has over 27 years of experience in RF engineering including extensive experience in wireless planning, RF design, optimization, and performance of wireless systems utilizing OFDM, CDMA, EVDO, GSM/GPRS/EDGE, UMTS/HSPA, LTE, SMR/IDEN and other wireless technologies. In his career, he was responsible for the specification, design, proof-of-performance tests, implementation, and optimization of numerous wireless communications systems, detection and measurement systems including advanced military systems. His career began in the specification, design, and implementation of underwater acoustic warfare systems and continued with commercial wireless communications systems while at V-COMM.

While at V-COMM, Mr. Hunt has been responsible for the performance of a RF engineering team supplying a variety of RF services to a diverse client group. Projects include: system performance monitoring, frequency planning, adjacent market coordination, inter-modulation analysis, RF propagation prediction, system technology evaluation. Mr. Hunt designed, tested, optimized, and maintained new and existing cellular, PCS, MMDS, SMR, 700 MHz and other wireless voice and/or data systems throughout the United States and the Caribbean. In addition, Mr. Hunt has been involved in special technology evaluations and the development and procurement of hardware and software engineering tools to enhance both V-COMM and its client's capabilities. Mr. Hunt has lead the development of tools and procedures to assist clients and carriers in meeting compliance with FCC Rules & Regulations for RF Safety, emission standards and other FCC regulatory issues including FCC, FAA and AM tower studies and filings. David's activities included the development and submission of comprehensive engineering studies for consideration in numerous FCC proceedings.

While at the Naval Air Warfare Center (NAWC), Mr. Hunt designed and wrote computer programs to generate and display antenna beam pattern for various conditions of a linear array of hydrophones for display of receiver gain calculations. He documented this work in Technical Memorandum 5032 TM-887-IBP-08. Mr. Hunt was involved in all aspects of the SSQ-101 Air Deployable Active Receiver (ADAR) sonobuoy development including: signal processing software, hardware design and development, test planning, setup and testing. Mr. Hunt designed, developed and implemented an All-Threat In-Buoy Signal Processing (IBSP) Program used to detect, classify and localize enemy targets on the SUN workstation using standard signal to noise ratio measurements and advanced detection methods. This involved analyzing signal to noise ratio performance requirements and the design/implementation of specific portions of the preprocessor including modulation, filter decimation, windowing with redundancy, frequency analysis, magnitude/phase detection and a short term integration process.

While at NAWC, he received seven Performance Awards, a Quality Step Increase, three Letters of Appreciation, and one Special Act Award.

Mr. Hunt has a Bachelor of Science Degree in Electrical Engineering from Temple University emphasizing Signal Processing, Digital Signal Processing and Communications. In addition, Mr. Hunt has earned a Masters of Science Degree in Electrical Engineering from Drexel University in Philadelphia.